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Groundwater Contamination in the Great Lakes Basin: Implications for Multimedia Remedial Actions

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GROUNDWATER CONTAMINATION IN THE GREAT LAKES BASIN: IMPLICATIONS FOR MULTIMEDIA REMEDIAL ACTIONS

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This response to the article by Mr. Hodge[1] focuses on the need for funding expensive multimedia remedial actions[2] because of the use and abuse of aquifer units in the Great Lakes Basin as described by the author. While Hodge has done a good job in setting the stage for discussion at this symposium, he does not go far enough in describing the extent of contamination in the basin, the institutional barriers to protecting groundwater, and the future policy implications of the current lack of a coordinated binational remedial effort. Institutional barriers that have prevented effective assessment, cleanup, and protection of the subsurface threaten to shift the economic burden for protection of public health and environmental quality from the private sector to the public sector. There are grave implications for the federal budget deficit in both nations if this policy is allowed to continue.

This response begins by underscoring the significance of Hodge's description of flow pathways and contamination of subsurface waters. Several additional examples of significant groundwater contamination with resulting surface water impacts are presented. Institutional barriers that promote the abuse Mr. Hodge describes are highlighted. A description of work accomplished by the International Joint Commission (IJC) under the Great Lakes Water Quality Agreement is described which places into focus the implications of not overcoming these barriers. The ramifications of not having had effective groundwater quality management implemented in both countries go beyond the "prevention of pollution" concept presented by Hodge.[3] There are serious present and future public health risks from toxic substances contamination in the Great

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1. Hodge, *Groundwater in the Great Lakes Basin: The Natural System, Use and Abuse, and Policy Implications*, 65 CHI.-KENT L. REV. 439 (1989).

2. The use of the term "multimedia remedial actions" refers to cleanup efforts that are needed to stop pollutants from being released from a multitude of areas (land-based industrial operations, dumpsites, contaminated groundwater, discharges to surface waters, runoff from industrial areas, and remediation of contaminated bottom sediments containing pollutants deposited from all sources).

3. Hodge, *supra* note 1, at 463.

Lakes Basin Ecosystem. We are no longer just creating risks for ourselves; we are placing our offspring at risk. Is this ethical? In addition, hundreds of billions of dollars worth of necessary remedial actions will be passed on to the next generation along with the health risks if this generation fails to overcome barriers to effective multimedia environmental management.

I. EMPHASIS ON THE GROUNDWATER FLOW CONCEPT

Mr. Hodge repeatedly notes in the paper that groundwater behaves in accordance with several basic principles. He describes the concept of groundwater flow, presents general hydrogeological conditions in the basin, and discusses use of subsurface waters. He points out that groundwater flow and its accompanying contaminants do not respect political boundaries and presents two examples—the St. Clair River and the Niagara River—to support his statement.[4] Hodge also identifies a difference between "older," more slowly moving regional groundwater and "newer," more rapidly moving shallow groundwater.[5]

The information Hodge presents is on the cutting edge of science with regard to groundwater flow paths. Many scientists now recognize that these shallow aquifer systems are very responsive to rainfall and that groundwater can have very significant impacts on tributary water quality not only during low flow but also as a result of precipitation. Unfortunately, many managers are not aware of this recent information and still believe that because regional, deep groundwater flow to the Great Lakes is small, inputs from groundwater are not important. Research is showing that much of tributary surface water flow has been in the subsurface at some point in time and that consequently, groundwater can have a large impact on the quality of surface water even in the Great Lakes Basin.[6]

Hodge discusses implications of the groundwater flow system concept and states that subsurface waters move under recognizable principles.[7] While he is correct, man's ability to recognize and predict groundwater flow, especially in the more dynamic shallow aquifers, is limited by nature's complexity, man's perturbations of natural flowpaths, and by lack of funding.

Hydrogeologists have spent most of their time researching the

4. *Id.* at 454-59.
5. *Id.* at 441.
6. *Id.* at 441-48.
7. *Id.* at 441.

deeper, more predictable aquifers. Shallow systems are more dynamic and can have complex geology. These preferred pathways of least resistance can accelerate groundwater flux and short-circuit the "protection" provided by geologic material. Furthermore, man's engineering improvements—ditches, underground utilities, storm/sanitary sewers, water lines, artificial fill material, etc.—provide significant short-circuiting pathways that efficiently speed contaminated groundwaters to discharge points in surface waters. Examples of the significance of this short-circuiting to surface quality are given for the Detroit area, the Niagara River, Gary, Indiana, and agricultural regions of Ohio/Indiana in the following section. The policy issue facing both nations is whether to spend billions of dollars in monitoring studies to define in precise terms these areas or, once the areas have been identified in general terms, to spend the funding on cleanup. Currently, we seem to be in the study mode.

II. Lack of a Regional Groundwater Quality Assessment

While Hodge describes groundwater contamination in the Niagara and St. Clair River regions, the article does not present a comprehensive regional assessment of groundwater quality. Hodge should not be faulted for this shortcoming. Such an assessment does not exist and there appears to be no movement in either country to take this necessary first step.

The International Joint Commission recognized this gap in the early 1980s. The IJC's Science Advisory Board assembled information from both Canada and the U.S. on potential contamination of the subsurface as part of its 1983 Report to the IJC.[8] Based on this synoptic survey, which showed a lack of information on contamination, the Board recommended that both countries conduct accelerated mapping of contamination so that policy decisions could be based on facts. As of December 1989, this recommendation was still not implemented and residents of the Great Lakes Basin remain in the dark on the basin-wide significance of groundwater contamination.

Despite the lack of widespread information across the basin, information on the significance of groundwater contamination in several parts of the U.S. portion of the basin is now becoming available. This appears to be a result of federal legislation regulating toxic waste disposal having

8. Groundwater Contamination Task Force of the Great Lakes Science Advisory Bd. of the Int'l Joint Comm'n, 1983 Annual Report, Appendix II, Groundwater Contamination (1985) [hereinafter Task Force].

been passed in the U.S.[9] Unfortunately, such federal legislation is not evident in Canada and groundwater quality investigations seem to have very low priority.

Widespread groundwater contamination seems to be present in older industrial areas exactly where it would be expected. Places such as the Niagara Falls area, Gary, Indiana, and Detroit have been studied and real concerns exist. While Hodge presents information on the Niagara Falls area, he fails to note that investigations show that groundwater does not behave predictably. Toxic contaminants from the many dozen waste sites flow quickly along preferential pathways such as abandoned sewer systems, storm sewers, fill material associated with water conduits, and are rapidly transferred to surface waters.[10] This is a transboundary issue of great political concern both because of degradation to Canadian water supplies and impairments in fishery and wildlife of Lake Ontario from these toxic substances.[11] A similar situation is encountered in the Gary, Indiana-Grand Calumet area with sewer systems and ditches serving as efficient collectors of up to 16 million gallons per day of contaminated groundwater from dozens of hazardous waste sites.[12] This short-circuiting contributes to severely degraded water quality in southern Lake Michigan.[13] Likewise, in the Detroit area, ditches and fill material traverse waste sites and provide short-circuiting pathways for contaminants to reach surface waters.[14] Waste materials dumped on shorelines and buried alluvial channels with highly permeable glacial materials in the Detroit area also help to expedite groundwater contaminants' transport to surface waters.

Contaminated groundwater in agricultural areas also contributes to

9. Superfund, 42 U.S.C. §§ 9601-9675 (Supp. V 1987) and The Resource Conservation and Recovery Act, 42 U.S.C. §§ 6921-6939(b) (Supp. V 1987), both first enacted about a decade ago, have provided the impetus to monitor groundwater contamination at waste sites. The states and the EPA now have access to site-specific data on groundwater contamination at these sites.

10. GRADIENT CORP./GEOTRANS, INC., POTENTIAL CONTAMINANT LOADINGS TO THE NIAGARA RIVER FROM U.S. HAZARDOUS WASTE SITES 29 (1988).

11. ENVIRONMENT CANADA, U.S. ENVTL. PROTECTION AGENCY, ONTARIO MINISTRY OF ENV'T, AND NEW YORK STATE DEP'T OF ENVTL. CONSERVATION, LAKE ONTARIO TOXICS MANAGEMENT PLAN 4 (1989).

12. Watson & Fenelon, *Geohydrology of a Thin Water-Table Aquifer Adjacent to Lake Michigan, Northwestern Indiana*, 1988 AM. WATER RES. ASS'N. 243.

13. Complex sources of pollutants affect southern Lake Michigan. It is not possible, given current funding constraints, to separate the different sources. Contaminated groundwater contributes to this problem. For a description of the complexity of pollution sources in this area, see U.S. ENVTL. PROTECTION AGENCY, MASTER PLAN FOR IMPROVING WATER QUALITY IN THE GRAND CALUMET RIVER/INDIANA HARBOR CANAL 1-8 (1985) (EPA 905/9-84-003C).

14. NON-POINT SOURCE WORK GROUP, WASTE DISPOSAL SITES AND POTENTIAL GROUNDWATER CONTAMINATION - DETROIT RIVER UPPER GREAT LAKES CONNECTING CHANNEL STUDY 9 (1988).

Great Lakes pollution. Concerns exist about soluble pesticides as well as nitrates from fertilizer application. A good example involves Lake Erie and the two-fold increase in nitrate concentrations during the 1980s reported by the IJC's Great Lakes Water Quality Board.[15] During the 1970s, an increase in fertilizer application and drainage of wetlands occurred in the Lake Erie basin of Ohio and Indiana as it has across the United States. Researchers have found that most of this nitrate comes from shallow groundwater recharging ditches through tile drains or shallow groundwater flow (interflow).[16] Scientists do not know what this increase in nutrients means to Lake Erie. Scientists also do not know what percentage of impairments in the Great Lakes is attributable to groundwater contamination.

The IJC has identified 42 Areas of Concern (AOCs) around the Great Lakes which have serious contamination from toxic substances. Since waste sites are located in virtually every area, it is plausible that contaminated groundwater contributes to degradation in many of these areas. The Niagara River, the Detroit River, and the Gary-Grand Calumet area are among these 42 AOCs noted in Table 1. Many studies are underway in AOCs as part of the preparation of Remedial Action Plans (RAPs) as recommended by the IJC. However, incomplete information is being provided to the IJC on the significance of groundwater contamination. In fact, the IJC's Great Lakes Water Quality Board indicated in its 1989 Report that it is not getting the type of groundwater quality data that it needs to evaluate progress.[17]

III. IDENTIFYING INSTITUTIONAL BARRIERS

Hodge attributes the lack of concern about groundwater contamination and lack of management of the problem to the recent awakening of decisionmakers to the groundwater situation after decades of folklore and legend.[18] Yes, that is a convenient excuse, but it has been 25 years since a comprehensive description of groundwater pollution (from virtually all imaginable cases of contamination) was published in Michigan.[19] However, institutional barriers to effective groundwater protection have been in place for years.

15. GREAT LAKES WATER QUALITY BD., 1989 REPORT ON GREAT LAKES WATER QUALITY 76 (1989) (Report to the International Joint Commission).

16. D. BAKER, SEDIMENT, NUTRIENT, AND PESTICIDE TRANSPORT IN SELECTED LOWER GREAT LAKES TRIBUTARIES 36 (1988) (U.S. Environmental Protection Agency, EPA 905/4-88-001).

17. GREAT LAKES WATER QUALITY BD., *supra* note 15, at 57.

18. Hodge, *supra* note 1, at 440.

19. TASK FORCE, *supra* note 8, at 22.

The absence of federal legislation in both countries mandating specific protection of groundwater has certainly contributed to groundwater contamination concerns. In Canada, groundwater protection (as with most all natural resources protection activity) is the purview of provincial governments rather than the federal government. Since the Canadian federal government, not provincial governments, signed the Great Lakes Water Quality Agreement, inter-jurisdictional matters are especially delicate. The lack of modern and comprehensive provincial legislation for groundwater protection, the lack of enforcement of existing authority, the lack of hydrogeologists (who flock to the U.S. for better salaries), and the weak role of the federal government are perceived as impairing cleanup and protection of subsurface waters.

In the U.S., a strong federal role in waste management and groundwater cleanup at hazardous waste sites has been created by Congress in the last decade.[20] This has resulted in billions of dollars of studies that hopefully one day will lead to resolution of sensitive groundwater contamination issues with transboundary ramifications such as the Niagara River-Lake Ontario problem. However, Congress has allowed state and local governments to struggle with other groundwater protection issues—with poor results.

Institutional barriers to effective groundwater protection in the U.S. portion of the Great Lakes Basin seem very similar to those I identified for the seven-state Tennessee Valley Authority region during the early 1980s.[21] Fragmentation of effort is encouraged by the existence of at least 16 federal statutes[22] that could be used to protect subsurface waters. Moreover, only a patchwork of legislation exists at the state level. Fed-

20. Superfund, 42 U.S.C. §§ 9601-9675 (Supp. V 1987) and The Resource Conservation and Recovery Act, 42 U.S.C. §§ 6921-6939(b) (Supp. V 1987).

21. Duda, *Unified Management of Surface and Groundwater Quality Through Clean Water Act Authorities*, 27 GROUNDWATER 357 (1987).

22. Fragmentation stems from different agencies administering at least 16 statutes, including: Atomic Energy Act of 1954, 42 U.S.C. §§ 2011-2296 (Supp. IV 1986); Clean Water Act, 33 U.S.C. §§ 1251-1387 (Supp. II 1984); Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464 (Supp. IV 1986); Federal Insecticide, Fungicide, and Rodenticide Act, 7 U.S.C. §§ 136-136(y) (1988); Federal Land Policy and Management Act, 43 U.S.C. §§ 1701-1784 (Supp. V 1987); Food Security Act of 1985, 16 U.S.C. §§ 3801-3845 (Supp. IV 1986); Resource Conservation and Recovery Act, 42 U.S.C. §§ 6921-6939(b) (Supp. V 1987); Hazardous Materials Transportation Act, 49 U.S.C. §§ 1801-2013 (Supp. V 1987); Hazardous Liquid Pipeline Safety Act of 1979, 49 U.S.C. §§ 1801-2013 (Supp. V 1987); National Environmental Policy Act, 42 U.S.C. §§ 4321-4370(a) (Supp. V 1987); Surface Mining Control and Reclamation Act, 30 U.S.C. §§ 1201-1211, 1231-1328 (Supp. IV 1986); Safe Drinking Water Act, 42 U.S.C. §§ 300(f)-300(j)-26 (Supp. V 1986); Superfund, 42 U.S.C. §§ 9601-9675 (Supp. V 1987); Toxic Substances Control Act, 15 U.S.C. §§ 2601-2671 (Supp. IV 1986); Uranium Mill Tailings Radiation Control Act, 42 U.S.C. §§ 2014, 2021, 2022, 2111, 2113, 2114, 2201, 7901, 7911-7925, 7941, 7942 (Supp. V 1987); Water Reclamation and Development Act, 43 U.S.C §§ 371-616yyyy (Supp. V 1987).

TABLE 1. JURISDICTIONS RESPONSIBLE FOR DEVELOPING REMEDIAL ACTION PLANS FOR THE 42 AREAS OF CONCERN IN THE GREAT LAKES BASIN

Responsible Jurisdiction	Areas of Concern by Lake Basin
	Lake Superior
Ontario	Peninsula Harbour
Ontario	Jackfish Bay
Ontario	Nipigon Bay
Ontario	Thunder Bay
Minnesota/Wisconsin	St. Louis River
Michigan	Torch Lake
Michigan	Deer Lake-Carp Creek-Carp River
	Lake Michigan
Michigan	Manistique River
Wisconsin/Michigan	Menominee River
Wisconsin	Fox River/Southern Green Bay
Wisconsin	Sheboygan
Wisconsin	Milwaukee Harbor
Illinois	Waukegan Harbor
Indiana	Grand Calumet River/Indiana Harbor Canal
Michigan	Kalamazoo River
Michigan	Muskegon Lake
Michigan	White Lake
	Lake Huron
Michigan	Saginaw River/Saginaw Bay
Ontario	Collingwood Harbour
Ontario	Penetang Bay to Sturgeon Bay
Ontario	Spanish River Mouth
	Lake Erie
Michigan	Clinton River
Michigan	Rouge River
Michigan	River Raisin
Ohio	Maumee River
Ohio	Black River
Ohio	Cuyahoga River
Ohio	Ashtabula River
Ontario	Wheatley Harbour
	Lake Ontario
New York	Buffalo River
New York	Eighteen Mile Creek
New York	Rochester Embayment
New York	Oswego River
Ontario	Bay of Quinte
Ontario	Port Hope
Ontario	Toronto Waterfront
Ontario	Hamilton Harbour
	Connecting Channels
Ontario/Michigan	St. Mary's River
Ontario/Michigan	St. Clair River
Michigan/Ontario	Detroit River
Ontario/New York	Niagara River
Ontario/New York	St. Lawrence River

eral agency policies run at cross purposes, and some programs seem to encourage and reward groundwater contamination.[23] Fragmentation of responsibility among agencies and among levels of government, unaddressed pollutants, unaddressed pollution sources, low funding priorities, and inadequate data collection/evaluation efforts make effective groundwater protection nearly impossible. Comprehensive monitoring, classification, and standards systems are not in place. With low funding priority, it is not surprising that the quality of groundwater data is often poor, systematic data collection efforts are absent, data interpretation is limited, paper files of data are virtually inaccessible, and important water quality parameters are not analyzed. When coupled with a regulatory emphasis on surface water to the virtual exclusion of groundwater, it is easy to see why groundwater is not being protected.

The International Joint Commission's role is to evaluate progress in cleaning up the Great Lakes Basin Ecosystem. Unfortunately, the IJC's Water Quality Board concludes in its 1989 Report[24] that it does not have the information needed to evaluate progress in controlling groundwater contamination as specified in Annex 16 of the Agreement for both countries. The Board calls for specific data to be collected and submitted so that it can begin to track progress.

IV. IMPLICATIONS FOR MULTIMEDIA REMEDIAL ACTIONS

While Hodge is well-founded in his conclusion that preventive strategies at the source are much less costly and therefore preferable to remedial measures,[25] he has not gone far enough in describing the implications of the contamination caused by toxic chemicals in the Great Lakes Basin Ecosystem. Not only are programs aimed at prevention needed, but also programs are needed to stop existing pollution at its source and then to remediate down-gradient or downriver impacts caused by contaminants having migrated from the site. The longer both countries wait to stop existing pollution at its source, the greater the offsite migration will be and the greater the ultimate cleanup cost will be.

23. Many of the policies stemming from the legislation cited in note 22 run at cross purposes and seem to encourage groundwater contamination. Some examples include: Clean Water Act permit conditions result in diverting pollutants from direct discharge to waters to disposal on the land (lagoons) or through underground injection, *see* 33 U.S.C. §§ 1251-1387; federal subsidies for water development projects in the West result in widespread contamination of groundwater through irrigated agriculture, *see* Water Reclamation Act, 30 U.S.C. §§ 1201-1211, 1231-1328; and agricultural commodity and subsidy programs have encouraged intensive agriculture with high use of chemicals—with resulting groundwater contamination, *see* Food Security Act of 1985, 16 U.S.C. §§ 3801-3845.

24. GREAT LAKES WATER QUALITY BD., *supra* note 15, at 57.

25. Hodge, *supra* note 1, at 463.

A good example of the implications of delay in remediation is the case of hazardous waste dumpsites along the Niagara River near Niagara Falls, New York. Jaffe and Hites have tracked specific chemicals in Lake Ontario to specific dumpsites in Niagara Falls.[26] Chemicals leaking from the site have long-range impact on Lake Ontario as they are transported across the entire lake and accumulate as contaminated sediments and in fish/aquatic life. These contaminants continue to cycle through the ecosystem, to bioaccumulate in fish and wildlife, and to result in chemically-induced diseases in them as well as health risks to humans consuming the fish.[27]

Unfortunately, many waste sites continue to leak toxic substances into the Great Lakes Basin. Many of these sites in the U.S. are not on the National Priorities List for superfund sites because the ranking system only considers downstream drinking water intakes, not bioaccumulation and exposure through consumption of fish. These sites thus receive low priority for cleanup, as noted by way of example in the Upper Great Lakes Connecting Channels Study.[28] Every day that passes without stopping the flow of toxic contaminants in groundwater to surface water just adds a greater load—and a greater economic cost for remedial actions—to down-gradient water bodies. These remedial action costs of assessing, removing, and disposing of in-place contaminated sediments exceed on-site cleanup costs perhaps by ten-fold, perhaps by even more. With at least four dozen areas of the Great Lakes Basin, including large portions of Lake Michigan and Lake Ontario, having contaminated sediments, the implications for remedial actions are immense. Delays in remediation of on-site cleanup mean that more toxic contaminants will move off-site, off-site rehabilitation costs will greatly increase, and liability for cleanup costs off-site will be hard to determine. These delays have significant implications for federal budget deficits in both countries. With liability for pollutant release impossible to prove, the government will be forced to fund cleanup. This certainly is not prudent public policy.

The U.S. Office of Technology Assessment estimates that national waste site cleanup costs will probably exceed 500 billion dollars.[29] With

26. Jaffe & Hites, *Fate of Hazardous Waste Derived Organic Compounds in Lake Ontario*, 20 ENVTL. SCI. TECHNOL. 267 (1986).

27. GREAT LAKES SCIENCE ADVISORY BD., 1989 REPORT 79 (Report to the International Joint Commission).

28. NON-POINT SOURCE WORK GROUP, *supra* note 14, at 23.

29. OFFICE OF TECHNOLOGY ASSESSMENT, U.S. CONGRESS, COMING CLEAN: SUPERFUND'S PROBLEMS CAN BE SOLVED 27 (1989) (U.S. Government Printing Office, Washington OTA-ITE-433).

over 3,200 hazardous waste sites and over 130 high priority superfund sites having been identified in just the U.S. portion of the Great Lakes Basin, on-site remedial costs could reach 65-85 billion dollars. This does not include complete remediation of off-site contaminated sediments and ecosystem rehabilitation, costs that would likely exceed on-site costs. Unfortunately, the two-decade delay in cleanup since scientists and educators have become concerned about the dumping and the discharge of toxic wastes has created an expensive legacy. With lack of attention to the problem, the relative contribution of point sources versus non-point sources versus contaminated groundwater to the in-place contaminated sediments problem will likely never be known except for a few well-studied areas. In these areas, groundwater has been a significant contributing factor in the need for multimedia land and water remedial actions.[30]

While the environmental damage to fish, aquatic life, and wildlife in the basin provides more than enough reason for aggressive funding of remedial actions, there are two even more cogent arguments for quickly making the transition from studies and planning to widespread implementation of multimedia remedial actions. The first is the risk to public health from eating fish. Each lake has fish advisories because of toxic substances contamination, which poses an unacceptable risk of cancer. The disadvantaged, Native Americans, and sports fishermen's families commonly consume the fish despite advisories and therefore their health is at risk from cancer-causing substances. Moreover, new evidence indicates that some of these chemicals are teratogens, that is, they interfere with development of young and with reproduction. As noted in the Great Lakes Science Advisory Board's 1989 Report to the IJC, there is direct, but limited, evidence that human health is being adversely affected by exposure to toxic chemicals in the Great Lakes Basin.[31] Offspring of women who commonly consume Lake Michigan fish were found to have lower birth weights, smaller head circumferences, and various behavioral impairments compared to children of non-fish eating mothers. This direct evidence adds even more urgency to the need for conducting remedial actions to stop the release of persistent toxic substances that are teratogenic in nature.

The second argument for hastening remedial efforts is simply that

30. The Niagara River-Lake Ontario case is the best example of a well-studied area. The Indiana Harbor-Lake Michigan case is becoming well-studied and is demonstrating significant groundwater contaminant inputs. However, the complexity of pollution sources and the prohibitive costs of investigation likely will preclude many other comprehensive investigations. *See* OFFICE OF TECHNOLOGY ASSESSMENT, U.S. CONGRESS, SUPERFUND STRATEGY 11-13 (1985) (U.S. Government Printing Office, Washington OTA-ITE-252).

31. GREAT LAKES SCIENCE ADVISORY BD., *supra* note 27, at 68.

the U.S. and Canada agreed in the 1978 Great Lakes Water Quality Agreement to virtually eliminate the discharge of persistent toxic substances in the Great Lakes Basin.[32] In 1987 both nations affirmed the strategy toward a goal of zero discharge of these toxic substances, not only from point source discharges but also releases from contaminated sediments and contaminated groundwater.[33] The only elements missing are funding commitments for remedial action programs and deadlines for virtually eliminating these releases of persistent toxic substances. The implications of not aggressively conducting these needed multimedia remedial action efforts seem fairly straightforward: (1) our offspring and their offspring will face increased health risks because of our inaction, and (2) the cost of remedial actions will be passed on to our offspring and the cost to them will be much greater than the cost would have been to us.

V. SUMMARY

Mr. Hodge has done a good job introducing the topic of groundwater contamination in the Great Lakes Basin. He presents information on the cutting edge of science with regard to the importance of shallow aquifers in quickly transmitting contaminants from the subsurface to surface waters and the potentially large impact that groundwater has on surface water quality in the basin. He could have gone a little further in describing short-circuiting of flow paths to surface waters. This response briefly presents examples of man's engineering improvements—ditches, tile drains, artificial fill material, underground utilities, storm-sanitary sewers and water lines—that speed groundwater contaminants to surface waters.

Hodge is not able to present a comprehensive assessment of groundwater contamination in the basin because only a preliminary one assembled in 1983 for the IJC has been prepared. Institutional barriers to preparation of this comprehensive assessment and to effective protection of underground waters are discussed. The lack of federal legislation in both Canada and the U.S. present almost impenetrable barriers to comprehensive protection of subsurface waters and the surface waters with

32. Great Lakes Water Quality Agreement of 1978, Nov. 22, 1978, United States-Canada, 30 U.S.T. 1383, T.I.A.S. No. 9257 Annex 12, 2(a)(i).

33. Abatement of releases of pollutants from contaminated sediments is in Annex 14 of the revised Agreement and similar commitments to abate contaminated groundwater are included in Annex 16. *Id., supra* note 32, at Annex 14, 2(c)(ii) & 3(a)(b); Annex 16 (iv), as amended Nov. 18, 1987.

which they intimately interact.[34]

While Hodge presents several policy implications of the use and abuse of groundwater, he does not go far enough in describing the implications for funding needed for multimedia remedial actions in both countries. Not only are programs aimed at protection needed but also programs aimed at on-site and off-site remedial actions are necessary to address contaminants that have migrated from the sites. Delays in on-site cleanup mean that more toxic contaminants will move off-site and off-site aquatic ecosystem rehabilitation costs will skyrocket. The enormous cost of these programs, perhaps in the hundreds of billions of dollars for the Great Lakes Basin, have grave implications for the federal budget deficits in both Canada and the U.S.

Institutional barriers have prevented effective assessment, cleanup, remediation, and future protection of the Great Lakes Basin Ecosystem. Aquatic life, fish, wildlife, and now children (in a survey of children of mothers who have frequently consumed Lake Michigan fish) have been found to be adversely impacted by persistent toxic substances disposed of in the basin's water and on the basin's land. It appears that we are incurring a massive environmental/water quality deficit quite analogous to the federal budget deficit. Just as payments to reduce federal deficits are being postponed, payments to reduce the environmental/water quality deficit have been postponed.

Work has begun to reverse this situation under the Great Lakes Water Quality Agreement. Commitments have been made by the U.S. and Canada to virtually eliminate releases of persistent toxic substances from wherever they are released in the ecosystem—air, point sources, in-place contaminated sediments and contaminated groundwater. Studies have been conducted and plans are being prepared. The challenge now is to make the transition to action—multimedia remedial action—quickly and effectively. The risk of not doing so is great—not only politically but also economically and socially if health risks described in the IJC's Great Lakes Science Advisory Board 1989 Report end up being widespread. The big losers will be our offspring and their offspring. Their health will be at risk because of our inaction, and the economic cost we transfer to

34. While the U.S. has legislation (Superfund and Resource Conservation and Recovery Act) that requires assessment and remediation of groundwater contamination at priority hazardous waste sites, this does not represent a comprehensive approach toward all significant sources of groundwater contamination. It also represents a more costly remedial approach after pollution has been caused rather than a less costly "pollution prevention" approach. In addition, many "Superfund" sites will not be thoroughly cleaned up because of funding limitations. *See supra* note 30. Canada has no comparable federal legislation, and fragmented provincial efforts are not sufficient as noted elsewhere in this symposium issue.

them through our inaction will be much greater than the cost would have been to us. Eventually, decisionmakers will have to address the question, "Is this ethical, is this moral?"